Manual PID Tuning


```
cost_manual = 612.0727
```

PID Gain Optimisation - ODE45

```
                                     First-order      Norm of
 Iter F-count            f(x)  Feasibility   optimality         step
    0       4   1.323707e+03    1.519e-02    2.395e+08
    1       8   6.583301e+02    6.949e-03    2.778e+07    1.732e+00


Converged to an infeasible point.

fmincon stopped because the size of the current step is less than
the value of the step size tolerance but constraints are not
satisfied to within the value of the constraint tolerance.

<stopping criteria details>
gains_interiorP = 3×1

  101.7317
    0.0055
    9.9655
```
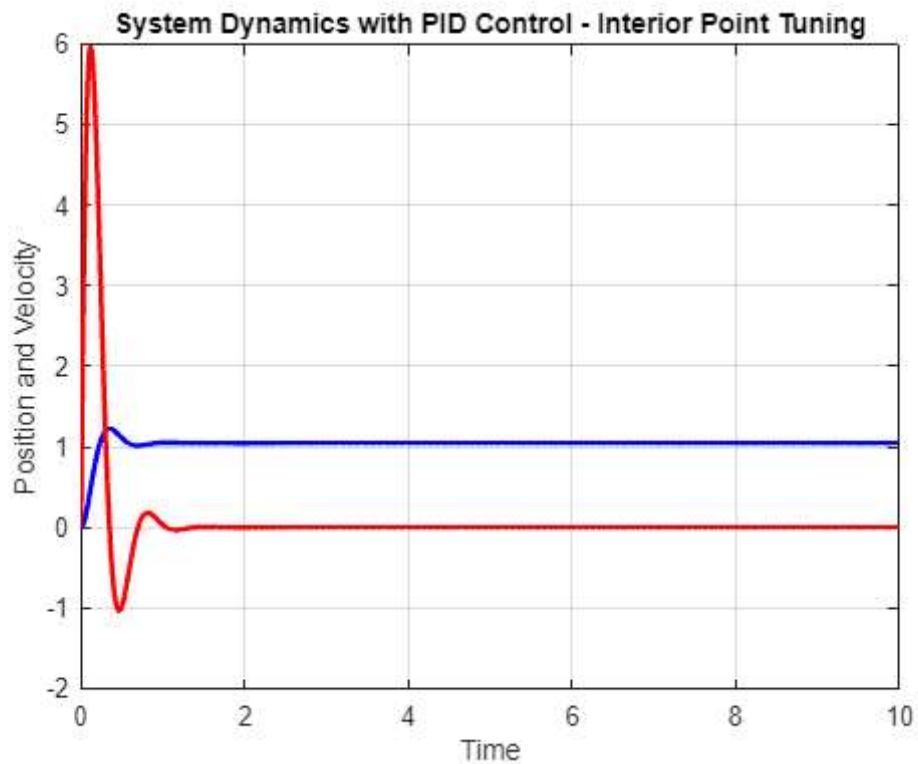
System Dynamics with PID Control - Interior Point Tuning

```
cost_interiorP = 1.4607e+03
```

PID Gain Optimisation - Genetic Algorithm

```
Single objective optimization:
3 Variable(s)
4 Nonlinear equality constraint(s)

Options:
CreationFcn:          @gacreationuniform
CrossoverFcn:         @crossoverscattered
SelectionFcn:         @selectionstochunif
MutationFcn:          @mutationadaptfeasible
```
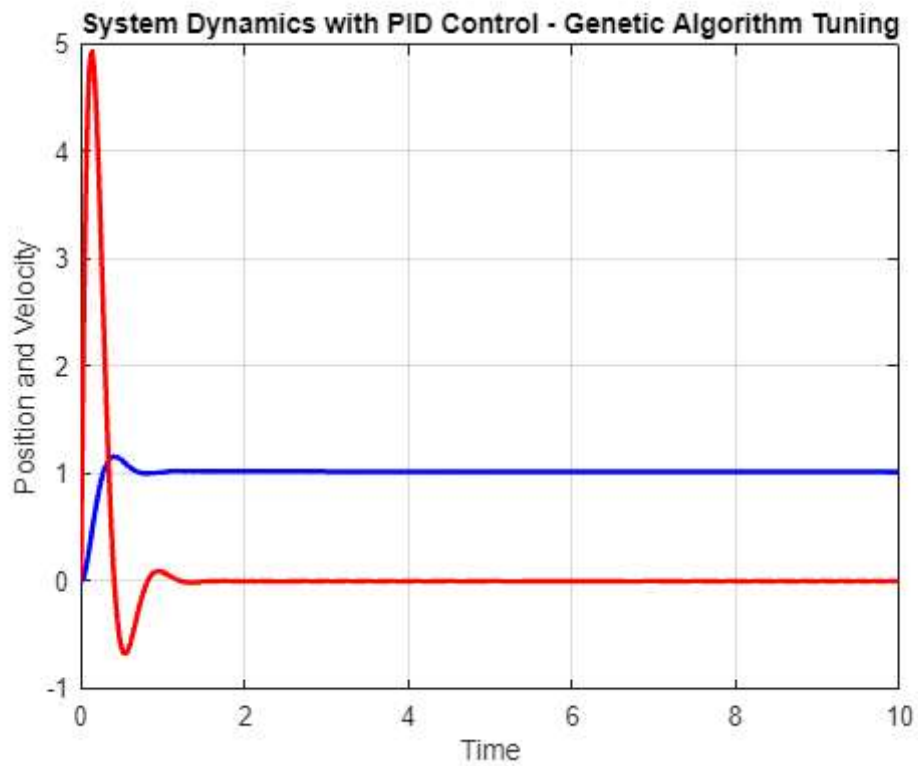
Generation	Func-count	Best f(x)	Max Constraint	Stall Generations
1	540	746.165	0.1034	0
2	1060	739.826	0.1	0
3	1580	734.465	0.09627	0

gains_ga = *1×3*

```
   78.5967    0.0101    9.6763
```

System Dynamics with PID Control - Genetic Algorithm Tuning

```
cost_ga = 1.3150e+03
```

PID Gain Optimisation - Particle Swarm

Iteration	f-count	Best f(x)	Mean f(x)	Stall Iterations
0	100	441.2	1989	0
1	200	159.6	2031	0
2	300	159.6	1439	1
3	400	159.6	1138	2
4	500	159.6	1084	3
5	600	159.6	873.9	4
6	700	159.6	1307	5
7	800	159.6	986.1	6
8	900	159.6	698.1	7
9	1000	159.6	519.2	8
10	1100	159.6	389.1	9
11	1200	159.6	1245	10
12	1300	159.6	605.7	11

gains_ps = *1×3*

```
   10.0000    0.0005    5.5422
```

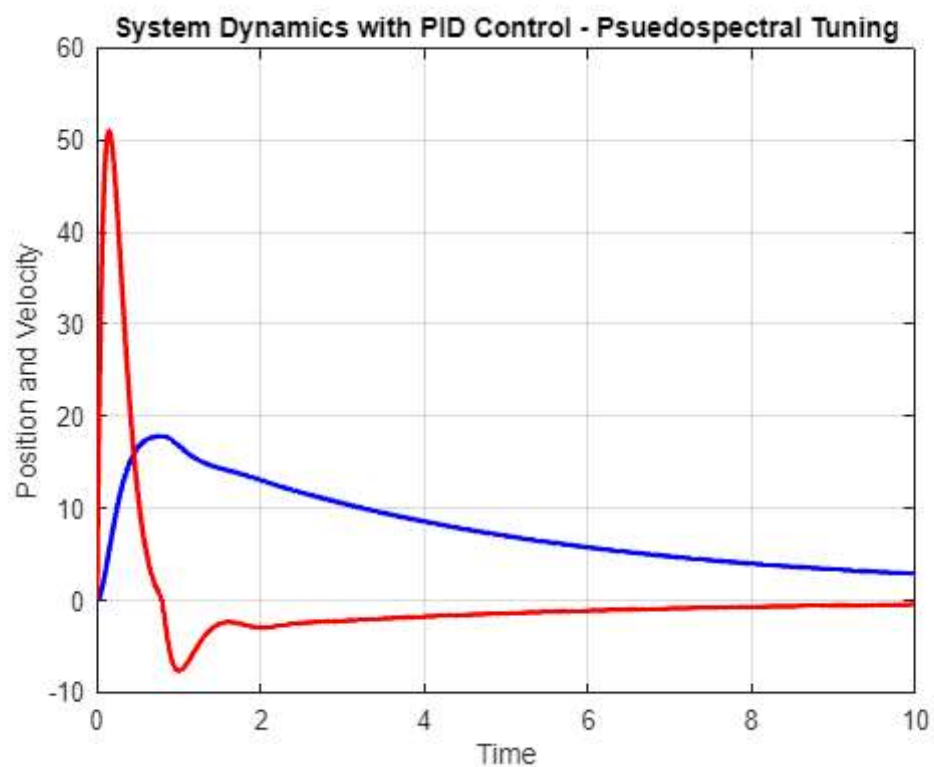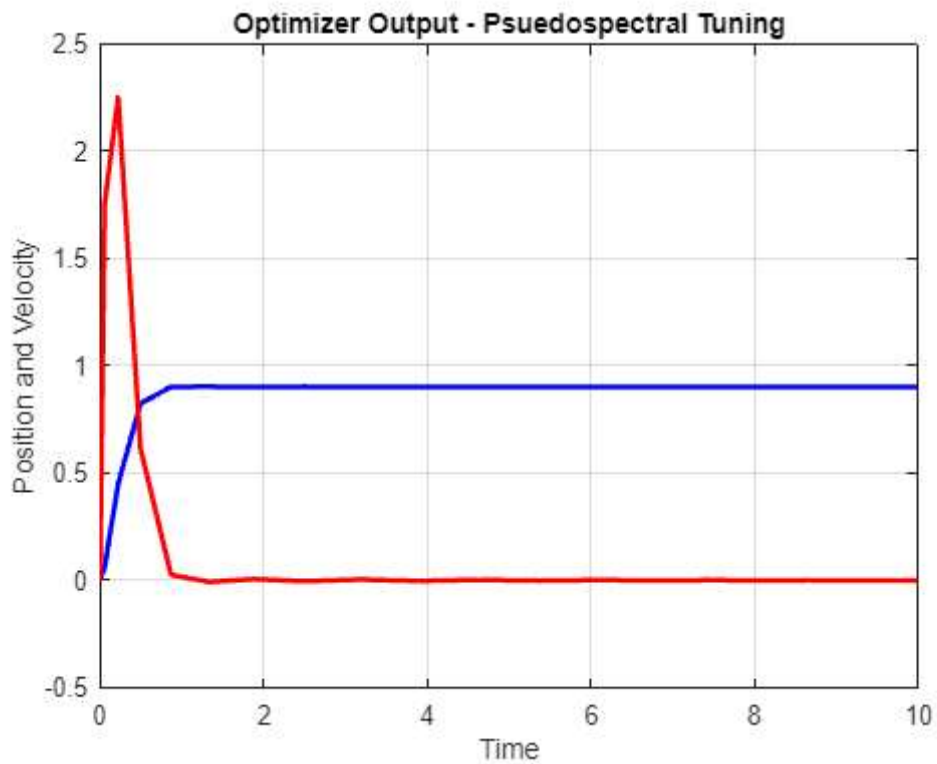System Dynamics with PID Control - Particle Swarm Tuning
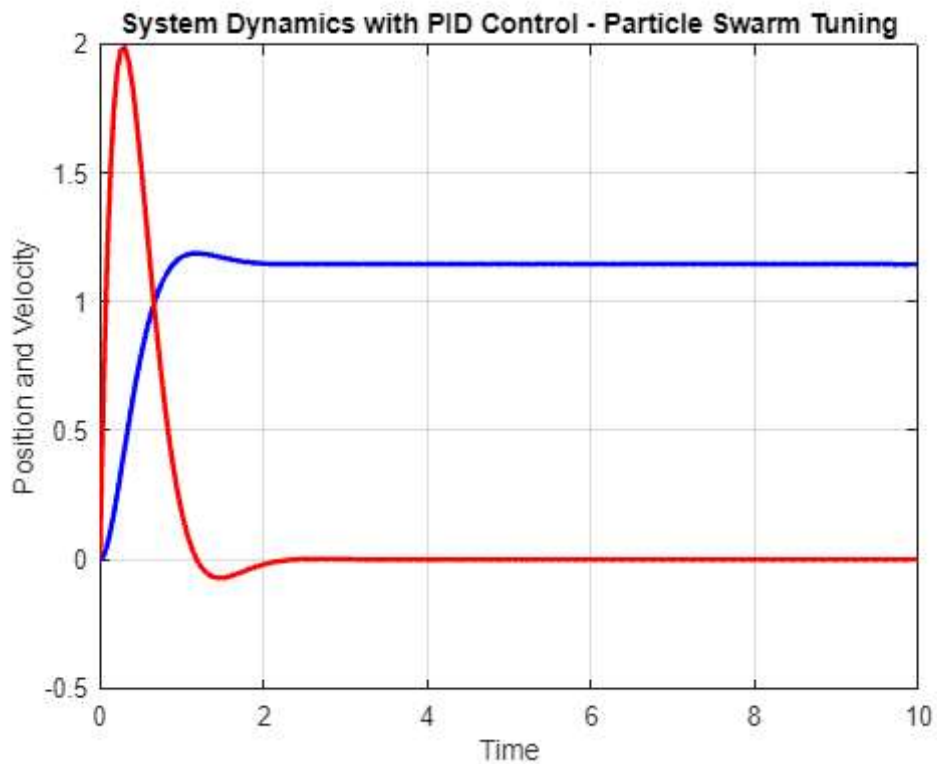
```
cost_ps = 394.1584
```

PID Gain Optimisation - with Pseudospectral Formulation

Iter	Func-count	Fval	Feasibility	Step Length	Norm of step	First-order optimality
0	111	9.988662e+00	1.000e+01	1.000e+00	0.000e+00	1.492e+00
1	222	5.877683e-01	4.950e+00	1.000e+00	6.849e+00	1.565e+03
2	333	7.434118e-01	3.393e-01	1.000e+00	1.571e+00	1.246e+03
3	444	7.766592e-01	2.479e-01	1.000e+00	4.257e-01	1.224e+03
4	559	7.723916e-01	2.451e-01	2.401e-01	2.269e-01	1.212e+03
5	682	7.706580e-01	2.444e-01	1.384e-02	6.581e-02	1.208e+03
6	807	7.687243e-01	2.437e-01	6.782e-03	5.868e-02	1.205e+03
7	934	7.665904e-01	2.432e-01	3.323e-03	4.774e-02	1.203e+03
8	1063	7.649162e-01	2.428e-01	1.628e-03	3.633e-02	1.201e+03
9	1192	7.632871e-01	2.424e-01	1.628e-03	3.573e-02	1.199e+03
10	1321	7.616790e-01	2.420e-01	1.628e-03	3.562e-02	1.198e+03
11	1448	7.584293e-01	2.412e-01	3.323e-03	7.268e-02	1.194e+03
12	1576	7.561800e-01	2.407e-01	2.326e-03	5.096e-02	1.191e+03

```
gains_psuedospectral = 1×3

    44.9336    0.0600    12.5120
```

Optimizer Output - Psuedospectral Tuning

System Dynamics with PID Control - Psuedospectral Tuning

```
cost_pseudospec = 4.3905e+03
```

Non-Linear Constraint for Pseudospectral Optimisation

System Dynamics Constraint Function - ODE

Cost Function

Input Calculator - PID - persistent variables

Spring Mass Damper System Dynamics

Chebyshev Pseudospectral Method